CAMBRIDGE TECHNICALS

Oxford Cambridge and RSA

CAMBRIDGE TECHNICALS LEVEL 3 (2016)

Examiners' report

ENGINEERING

05822–05825, 05873

Unit 3 Summer 2022 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

Unit 3 series overview

This Level 3 paper examined the principles of mechanical engineering. It followed a similar format to previous papers.

To do well on this paper, candidates needed to:

- be familiar with all the parts of the specification examined
- to show clear and legible workings especially for 2, 3 and 4 mark questions
- to attempt all questions
- to be familiar with and make appropriate use of the formula booklet
- to be familiar with and make use of engineering language and terms.

The paper appeared to be accessible with most questions being attempted by most candidates from most centres. However, candidates from some centres demonstrated limited understanding of resolution of forces in particular directions and the application of the principle of moments.

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
• used appropriate engineering language • showed clear working in calculations • attempted all questions • converted units correctly • showed familiarity with all parts of the specification including resolution of forces and the principle of moments.	• made mistakes in calculations • used incorrect engineering language • were less familiar with some parts of the specification including resolution of forces and the principle of moments • were unfamiliar with the contents of the formula booklet.

Question 1 (i)

1 **(i)** A standard concrete brick is a cuboid with dimensions 215 × 102.5 × 65 mm.

The density of concrete is 2100 kg m^{-3}.

Calculate the mass of **one** concrete brick.

....

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....

....

.... **[4]**

Candidates were expected to calculate the volume of the block and to use their calculated value to calculate the mass of one brick. Most candidates scored the first 2 marks for calculating the volume (ignoring POT errors). Many then used the correct method to calculate the mass and scored all 4 marks. Some had a POT error in their final error so scored 3 marks.

Question 1 (ii)

(ii) The bricks are stacked on a pallet ready to be transported.

The coefficient of friction between a brick on the top layer and the layer below it is 0.4.

Calculate the maximum horizontal force allowable before a brick on the top layer can slide relative to the layer below it.

....

....

.... **[2]**

Candidates were expected to calculate the horizontal force. Many scored both marks. Some scored one mark by writing 0.4 x 120 (or 80).

Question 1 (iii)

(iii) A wall is built using the bricks.

Fig. 1 shows the side elevation view of the wall aligned within a coordinate system, (x, y), with the origin at point O.

All dimensions shown are in metres.

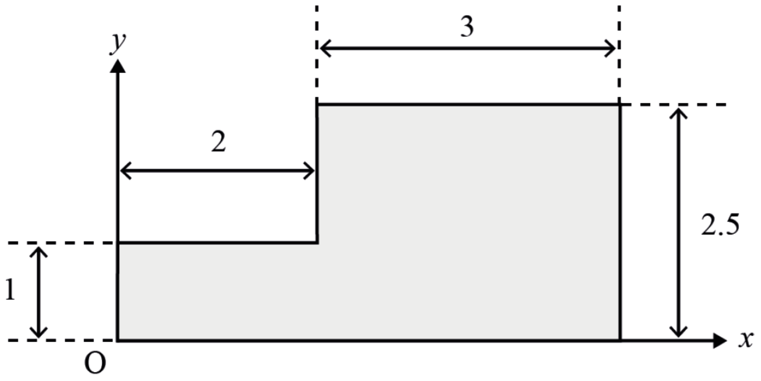

Fig. 1

Calculate the x-coordinate and the y-coordinate of the centroid of the side elevation.

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....

.... **[5]**

Candidates were expected to calculate the coordinates of the centroid. Many candidates scored 5 marks for calculating both ordinates correctly. Some scored 4 marks if one of the ordinates was calculated correctly. Many less successful responses scored 2 marks for stating 2 of Mass, x ordinate and y ordinate for each shape selected. Some of these candidates scored an extra mark by using the correct approach but with arithmetic error(s).

Question 2 (a) (i)

2 **(a)** **Fig. 2** shows a design of a base-plate.

All dimensions shown are in millimetres.

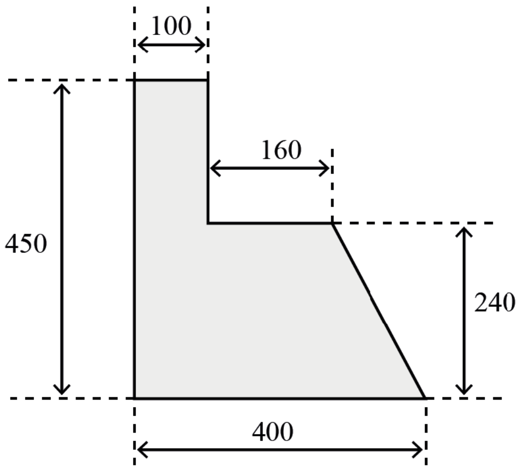

Fig. 2

(i) Calculate the area of this plate.

Give your answer in units of square millimetres.

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....

....

.... **[2]**

Many candidates scored both marks for calculating the correct value of area. Some scored one mark by dividing the area into simple shapes and calculating the individual areas but with some arithmetic errors.

Question 2 (a) (ii)

(ii) Convert your answer from part **(i)** into units of square centimetres.

....

.... **[1]**

Candidates were expected to divide their response to part (i) by 100. Many did this correctly and scored 1 mark.

Question 2 (b) (i)

(b) An engineer is using a machine that applies an axial compressive force to a cylindrical titanium rod.

During testing the rod is subjected to a range of stress values within the elastic limit and a graph of stress against strain is produced.

The engineer calculates that the gradient of the graph remains constant with a value of 114 GPa.

(i) State what is represented by the gradient of this graph.

.... **[1]**

Candidates were expected to recall that the gradient is equal to the Young's modulus or the stiffness. Most candidates scored 1 mark.

Question 2 (b) (ii)

(ii) Calculate the strain in the titanium rod when it is subjected to a stress of 600 MPa.

....

....

....

.... **[2]**

Candidates were expected to use the correct relationship to calculate the strain. Many candidates scored 2 marks, but some scored just 1 mark due to a POT error. Many candidates identified the correct relationship but did not apply it correctly and so were given no marks.

Question 2 (b) (iii)

(iii) When the stress in the rod is 600 MPa, its diameter is measured as 12.2 mm.

Calculate the force that was applied by the machine.

State the units in your answer.

....

....

....

....

....

.... **[3]**

Candidates were expected to calculate the area of cross section of a circle and to use this in the defining equation for stress. There was a separate mark for writing down the correct unit. Many candidates scored 3 marks. Some candidates identified the correct equation but did not apply it correctly and scored no marks (or 1 mark if the correct unit was seen). Many candidates scored 2 marks either because they omitted the unit or because the had a POT error.

Assessment for learning

In questions such as this one, it is important that candidates are aware of the importance of showing their working out. This can help avoid errors.

Question 3 (a) (i)

3 (a) **Fig. 3** shows a diagram of a lever used to lift a load of 500 N.

It has a Mechanical Advantage (MA) of 0.64.

The input force, F_I, is x m from the load and 0.55 m from the fulcrum.

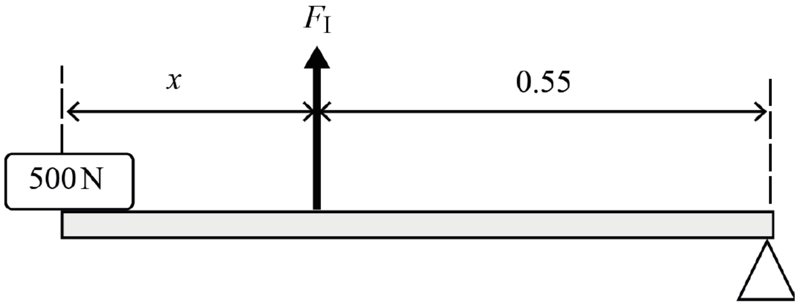

Fig. 3

(i) State the class of lever shown.

.... **[1]**

Candidates were expected to recall and distinguish between the classes of lever. Many candidates scored the mark by identifying this as a third-class lever. Many thought that it was a class two lever and scored no marks.

Question 3 (a) (ii)

(ii) Calculate the minimum value of the input force required to lift the load.

....

....

.... **[2]**

Candidates were expected to use the relationship between MA, input force and output force to calculate the input force. Many candidates did this correctly and scored 2 marks. Some candidates used the correct method but made an arithmetic error and scored 1 mark. Some candidates identified the correct relationship but were unable to rearrange it correctly. This received no credit.

Question 3 (a) (iii)

(iii) Calculate the distance *x*.

....

....

....

.... **[2]**

Candidates were expected to calculate an unknown distance using either the principle of moments from first principles or the relationship between MA and distances. Some did this correctly and scored 2 marks. Most candidates who did not give the correct response were not given compensation for their working so scored no marks. As there was only 1 compensation mark available, candidates who used the MA approach did not receive credit for a response of 0.86. Some candidates who used the principle of moments approach did score 1 mark for their working.

Question 3 (b) (i)

(b) A compound spur gear system is shown in **Fig. 4**.

Gear A is the input gear with 40 teeth and gear D is the output gear with 30 teeth.

Gear B has 20 teeth and rotates on the same shaft as gear C which has 10 teeth.

Gear A meshes with gear B and gear C meshes with gear D.

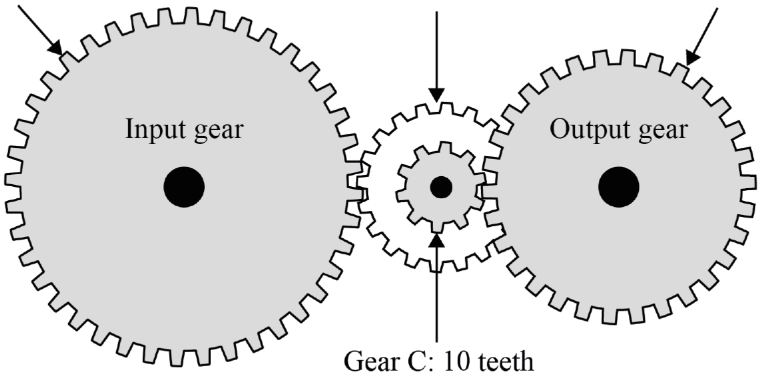

Fig. 4

(i) Calculate the overall Velocity Ratio (VR) of this system.

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.... **[3]**

Candidates were expected to calculate the overall velocity ratio of the gear change by dividing the product of the drivers by the product of the driven gears. As a general rule, candidates should give their calculated responses to an appropriate number of significant figures. In this case a response given as a fraction was given full credit. Many candidates who attempted to give a calculated value did not give a response correctly rounded to 2 significant figures. This scored a maximum of 2 marks.

Assessment for learning

Centres should make sure that when questions require calculations, responses should be given to appropriate number of significant figures and rounded correctly. Centres should also make sure that candidates understand what is meant by “appropriate” in this respect.

Question 3 (b) (ii)

(ii) Calculate the Mechanical Advantage (MA) of this system.

....

.... **[1]**

Candidates were expected to recall that VR is the inverse of MA. Many candidates wrote the expected response or used their incorrect response from Question 3bi and scored 1 mark.

Question 3 (b) (iii)

(iii) A gear can be inserted into this system to cause the output gear to rotate in the opposite direction to the input gear while keeping the overall Velocity Ratio the same.

Name this type of gear.

.... **[1]**

Candidates were expected to recall types of gear, and many did this successfully.

Question 4 (i)

4 **Fig. 5** shows a diagram of a trolley used to transport components around a factory.

The trolley has a mass of 40 kg, while the mass of the load varies.

The total normal reaction force of the floor on the trolley is R N.

The trolley is being pushed with a horizontal force of P N.

There is also a resistance force, F N = 0.2 × R N acting in the opposite direction to P.

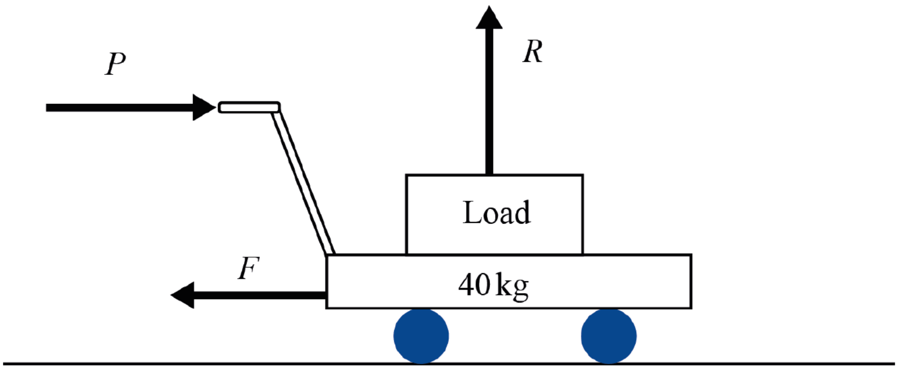

Fig. 5

(i) Calculate the value of the resistance force F on the trolley when it is carrying a load of 80 kg.

....

....

.... **[2]**

Candidates were expected to calculate the force applied by the mass due to gravity and then to calculate the frictional force. Many candidates omitted "g" and therefore received no credit.

Question 4 (ii)

(ii) Calculate the maximum load that the trolley can carry so that it will start to move when pushed with a force of 450 N.

....

....

....

.... **[3]**

Candidates were expected to calculate the normal reaction force and to divide this by g to find the maximum load. Many candidates scored no marks because they did not calculate the reaction force and did not divide by g. Most candidates who calculated the reaction force went on to divide by g and to score 3 marks.

Question 4 (iii)

The magnitude of P is changed such that the trolley now has a constant acceleration of $0.082\,\mathrm{m\,s^{-2}}$.

The load is again 80 kg.

(iii) Calculate the magnitude of the pushing force P.

....

....

....

.... **[3]**

Candidates were expected to apply Newton's 2nd Law in the horizontal direction. Many scored 1 mark for correctly witing down the right-hand side of this equation (but allowing for mass of 40 or 80). Relatively few candidates were able to write down the left-hand side of the equation.

Assessment for learning

Centres should make sure that candidates understand the meaning of "F" in the equation F = ma. F is the resultant force which frequently comprises a number of forces.

Question 4 (iv)

(iv) Assuming that the trolley starts from rest calculate the time it would take for it to reach a speed of $0.65\,\text{m}\,\text{s}^{-1}$.

....

....

.... **[2]**

Candidates were expected to select the appropriate suvat equation and to calculate the time. Many candidates did this successfully and scored 2 marks. Some candidates selected the correct equation but did not substitute the correct values and scored no marks.

Question 4 (v)

(v) Calculate the work done by the person pushing the trolley during this period.

....

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....

.... **[3]**

Candidates were expected to select the appropriate suvat equation and to calculate the distance. They were then expected to use this value together with the force to calculate the work done. Many used speed = distance/time which is not appropriate in this case and so gained no credit.

Question 5 (i)

5 **Fig. 6** shows a rigid body with corners A, B, C and D that is subjected to three co-planar forces with magnitudes 150 N, 300 N and 200 N.

All dimensions shown are in metres.

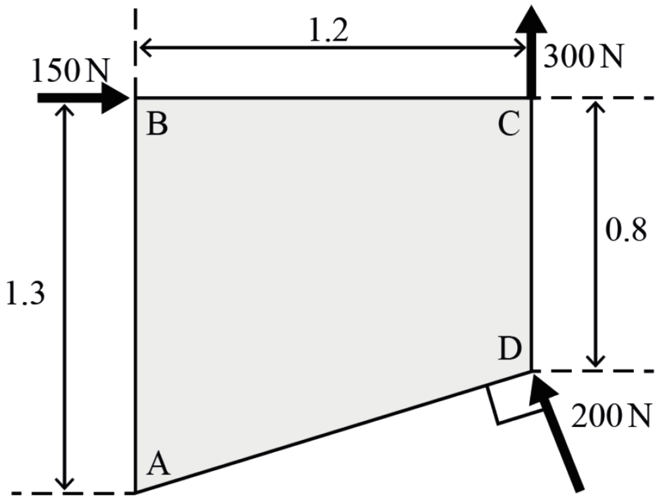

Fig. 6

(i) Calculate the length of the side AD.

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.... **[2]**

Most candidates used trigonometry correctly to calculate the correct response.

Question 5 (ii)

(ii) Calculate the moment around corner A.

....

....

.... **[3]**

A minority of candidates were able to calculate all 3 moments correctly and add them together (taking into account direction) to find the correct response. Many scored 1 mark for calculating one or two of the terms correctly.

Question 5 (iii)

(iii) Calculate the magnitude of the resultant force acting on the rigid body.

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....

.... **[5]**

Candidates were expected to calculate an appropriate angle and to use this to find the vertical and horizontal components of the resultant force. They were expected to use these to find the resultant. Very few candidates were able to calculate the correct response. Many seemed unfamiliar with how to resolve forces. Very few candidates from most centres scored more than 1 mark on this question.

Assessment for learning

It is important that candidates understand how to resolve forces in particular directions.

Question 6 (a)

6 (a) State the type of support that is found at each end of an encastre beam.

.... **[1]**

Most candidates did not recall the correct type of support.

Question 6 (b)

(b) For a simply-supported beam, name the type of support that can provide a vertical reaction force, no horizontal reaction force, and no moment.

.... **[1]**

Most candidates did not recall the correct type of support.

Question 6 (c)

(c) **Fig. 7** shows a simply-supported beam of length 12 m with supports A and B.

The beam is subjected to two vertical point loads with magnitudes 12000 N and 15000 N and a uniformly-distributed load of 2000 N m^{-1}.

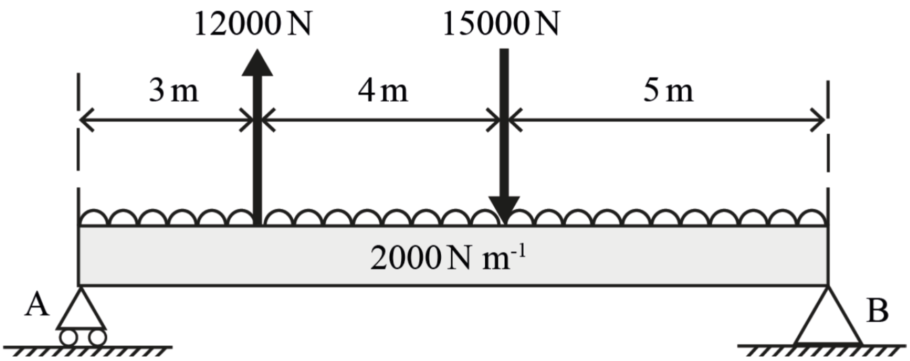

Fig. 7

Calculate the magnitude of the reaction forces at the supports A and B.

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.... **[5]**

Many candidates scored at least 1 mark by attempting to write down an expression for the moments about one end of the beam. A relatively small number dealt correctly with the distributed load, and this restricted their marks to a maximum of 2. Many candidates scored no marks. Candidates from a small number of centres did very well on this question, dealing correctly with the distributed load, taking moments, and applying vertical equilibrium correctly, and calculating both responses correctly.

Assessment for learning

It is important that candidates understand how to apply the principle of moments in beam questions.

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